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METHOD OF FORMING GATE IN SEMICONDUCTOR DEVICE

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METHOD OF FORMING GATE IN SEMICONDUCTOR DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method of forming the gate in the semiconductor device, and more particularly, to the method of forming the gate in the semiconductor device, which can prevent abnormal oxidization and lifting at the interface of the stack gate consisting of polysilicon and a metal and can be applied to even the single metal gate, by replacing a re-oxidization process for recovering damage of the gate oxide film generated in the gate patterning process with the oxygen plasma treatment.

Background of the Related Art

In the conventional process of forming the gate electrode using the polysilicon film, the re-oxidization process was performed for the purpose of recovering micro-trench and damage occurring in the gate oxide film when the polysilicon film is etched and increasing reliability by oxidizing the electrode material remaining in the semiconductor substrate and increasing the thickness of the gate oxide film at the gate edge. It is inevitable to perform the re-oxidization process since the thickness and film quality of the gate oxide film at the gate edge significantly influences hot carrier properties, sub-threshold properties (off-leakage, GIDL, etc.), punch-through properties, the operation

speed of the device, reliability, and the like.

In recent years, in order to lower the resistance of the gate, the polysilicon film and the metal film are stacked to form the gate. The stack structure of the polysilicon film and the metal film, however, has such problems as rapid dimension expansion, an increase in the surface resistance, etc. in a subsequent high temperature annealing process or the oxidization process. In particular, the most significant problem in the process is that lifting, etc. occurs since the metal film is oxidized in a given oxidization atmosphere. A new process that was developed in order to overcome this is the selective oxidization process. In other words, in this process, the metal film is not oxidized but only the polysilicon film and the semiconductor substrate are oxidized, in a hydrogen (H_2) rich oxidization atmosphere. However, the current selective oxidization process has a condition that it is possible when the tungsten film or the tungsten nitride film is used as the metal gate electrode. Further, as this oxidization process is possible in the H_2 rich atmosphere and at a very high temperature of 700℃, it may have influence on the characteristic of the MOSFET device.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a method of forming the gate in the semiconductor device capable of stably improving the operational characteristic by preventing oxidization at the interface of the polysilicon film and the metal film in the re-oxidization process.

Another object of the present invention is to provide a method of forming the gate in the semiconductor device wherein the oxidization process implemented at low temperature can be applied even to the single gate of the metal film as well as the stack gate of the polysilicon film and the metal film, while preventing abnormal oxidization or the lift phenomenon from being generated.

In the case where the re-oxidization process is performed using high temperature annealing at oxygen or H_2O atmosphere, oxygen that is diffused through the grain boundary and the bulk as well as the surface of the metal film due to very high temperature can oxidize the inside of the metal film and the interface of the polysilicon film and the metal film. For this reason, abnormal oxidization, lifting, and the like may occur. If the plasma oxidization process is performed at low temperature in lieu of high temperature annealing of the oxygen atmosphere, there is an advantage that only the surface of the stack gate of the polysilicon film and the metal film can be re-oxidized. Further, if high temperature annealing is implemented at nitrogen or hydrogen atmosphere after oxygen plasma treatment, the surface oxide film having much better characteristic can be obtained. Furthermore, this method can be applied irrespective of the type of the metal.

To achieve the above objects, according to the present invention, there is provide d the method of forming the gate in the semiconductor device, including the steps of forming a gate pattern on which a gate oxide film and a conductive layer are stacked at a give region on a semiconductor substrate, performing oxygen plasma treatment to form oxide films at the sides of the

conductive layer, and performing an annealing process for improving the film quality of the oxide film.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be apparent from the following detailed description of the preferred embodiments of the invention in conjunction with the accompanying drawings, in which:

FIG. 1A ~ FIG. 1C are cross-sectional views of semiconductor devices for explaining the method of forming the gate in the semiconductor device according to a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the preferred embodiment of the present invention, examples of which are illustrated in the accompanying drawings. FIG. 1A ~ FIG. 1C are cross-sectional views of semiconductor devices for explaining the method of forming the gate in the semiconductor device according to a preferred embodiment of the present invention.

Referring to FIG. 1A, a gate oxide film **12** and a polysilicon film **13** are formed on a semiconductor substrate **11**. In order to remove a native oxide film formed on the polysilicon film **13** in the process of forming the polysilicon film **13**, a cleaning process using a solution containing HF is performed. Next, an anti-diffusion film **14**, a metal film **15** and a hard mask **16** are sequentially formed on the entire top surface. The hard mask **16**, the

metal film **15**, the anti-diffusion film **14** and the polysilicon film **13** are then patterned by means of the mask process and the etch process, thus forming a gate pattern.

In the above, the gate oxide film **12** is formed using a silicon oxide film such as SiO_2, SiOxNy, etc. or high-dielectric metal oxide containing Hf or Zr such as HfO_2, ZrO_2, Hf-Al-O, Zr-Al-O, Hf-silicate, Zr-silicate, and the like. Further, the polysilicon film **13** is formed using a doped polysilicon film. Also, the anti-diffusion film **14** may be formed using WNx, the stack film of W and WNx, the stack gate of Wsix and WNx, TaSixNy or TiAlxNy, wherein x and y have a value of 0.03～3.00. Furthermore, the metal film **15** may be selectively formed using W, Ta, TaN, Ti or TiN. Meanwhile, it is preferred that the anti-diffusion film 14 and the metal film **15** are formed using the same series of materials in order to simplify the process. If the anti-diffusion film **14** is formed using WNx, the stack film of W and WNx or the stack film of Wsix and WNx; the metal film **15** is formed using W. If the anti-diffusion film **14** is formed using TaSixNy, the metal film **15** is formed using Ta or TaN. If the anti-diffusion film **14** is formed using TiAlxNy, the metal film **15** is formed using Ti or TiN. Also, the anti-diffusion film **14** is formed in thickness of 10～300Å and the metal film **15** is formed in thickness of 100～1000Å.

By reference to FIG. 1B, oxygen plasma treatment is implemented to oxidize the edge portion of the gate oxide film **12**, i.e., the sides of the polysilicon film **13**, the anti-diffusion film **14** and the metal film **15**, thus forming oxide films **17**. The oxygen plasma treatment is performed by

applying the RF source power of 100～3000W and the RF bias power of 0～100W. Further, the oxygen source for the oxygen plasma treatment may include a gas containing oxygen such as O_2, O_3, N_2O, NO, H_2O, or the like, or a mixture of them. Also, the oxygen plasma treatment is implemented using both oxygen and hydrogen as a plasma source. In order to use oxygen and hydrogen as the plasma source together, the flow ratio of oxygen/hydrogen is set to 0.01～0.2. Meanwhile, the oxygen plasma treatment is implemented by setting the temperature of the substrate to be 0～450℃. Upon the oxygen plasma treatment, ultraviolet rays are illuminated on the top of the substrate in order to increase surface oxidization reaction.

With reference to FIG. 1C, in order to improve the characteristic of the oxide film **17** formed by oxygen plasma, annealing is performed at a temperature of 600～1000℃ for 10seconds～60minutes nitrogen, hydrogen, argon or vacuum atmosphere that does not contain oxygen.

If the oxygen plasma treatment proposed by the present invention is performed, the edge of the gate oxide film and the surface of the gate are easily oxidized by oxygen radical that is activated by plasma at relative low temperature. As oxidization is not easily diffused since temperature is low, the inside of the gate is not oxidized. This has an advantage that oxidization at the interface of the polysilicon film and the metal film due to the high temperature re-oxidization process or selective oxidization can be prevented. Even in case of the metal gate for which selective oxidization is impossible, the re-oxidization process is possible by using the above method. In another embodiment of the present invention, the gate may be formed using the anti-

diffusion film and the metal film without forming the polysilicon film, and the oxidization process may be performed.

As described above, the present invention has a new effect that it can accomplish a stable operational characteristic of the device by preventing oxidization at the interface of the polysilicon film and the metal film due to the high temperature re-oxidization process or the high temperature selective oxidization process since only the surface of the gate is oxidized. Further, the present invention has an advantage that it can be applied to the gate electrode of various metals since the re-oxidization process is possible by the present method even in case of the metal gate for which selective oxidization is impossible. Therefore, the present invention has a new effect that it can manufacture the single gate MOSFET of the metal film as well as the stack gate of the polysilicon film and the metal film.

The forgoing embodiments are merely exemplary and are not to be construed as limiting the present invention. The present teachings can be readily applied to other types of apparatuses. The description of the present invention is intended to be illustrative, and not to limit the scope of the claims. Many alternatives, modifications, and variations will be apparent to those skilled in the art.